

Grant Title: The Soft X-Ray Transient Cen X-4 in Quiescence

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The initial goal of this project was to examine the quiescent X-ray light curve of the recurrent X-ray/optical nova Cen X-4 throughout its 15.1-hr orbital period. Using these observations the pre-outburst conditions of the binary would be investigated and the relationship between soft X-ray transients and persistent low-mass X-ray binaries would be established. *ROSAT*-PSPC observations were scheduled for 1991 August 9-13. Unfortunately, failure of the satellite's attitude control system near the end of the all-sky survey severely curtailed science operations for much of 1991, and the requested observations of Cen X-4 were never taken.

Since the stated goal could not be accomplished, the time and resources of this project were used in support of two other *ROSAT* programs for which I am co-investigator: "Identification of LMC X-ray Sources Using *ROSAT*-HRI Images" and "X-ray Light Curve for an Eclipsing Black-Hole Binary". Below, the results of these investigations are described.

The identification program was directed at understanding the global characteristics of LMC X-ray sources so that they can be compared to Galactic sources. During AO1 and AO2, 18 pointed *ROSAT*-HRI observations were obtained for a sample of optically unidentified LMC X-ray sources that were first detected with the *Einstein*-IPC. Twenty previously known sources were found while seven of the *Einstein* sources were not seen, although the *ROSAT* integration times were adequate. Apparently, these objects have variable X-ray emission. In addition, ten serendipitous sources were detected by *ROSAT*. Using the much more accurate positions from *ROSAT*-HRI ($\sim 4''$ versus $\sim 30''$ from *Einstein*-IPC), we have initiated a program at CTIO to find the optical counterparts of the yet unidentified X-ray sources. A total of 13 identifications have been made to date, including three AGN, seven galactic foreground stars, and three unusual hot stars in the LMC. The latter group is an example of the type of finding that we had hoped to uncover, and a detailed study of these objects is in progress at CTIO. Early results of our X-ray/optical survey has been presented at several conferences and a major summary will be submitted for publication in the near future.

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The other program that received our redirected attention was a study of the X-ray light curve of the black-hole candidate CAL 87, which is also a member of the LMC. *ROSAT*-PSPC data were obtained throughout its 10.6-hr orbital period, including two observations at predicted times of optical eclipse. Whereas the visual bandpass eclipse has a depth of ~ 1.3 mag (i.e., the flux is reduced by $\sim 70\%$) and lasts about half an orbital cycle (i.e., $\sim 0.5P$), the X-ray data show a much shorter and shallower eclipse. As recorded by the PSPC, the depth is $\sim 40\%$, and the duration is $\sim 0.2P$. These characteristics suggest that the X-ray region is only partially occulted. Similar phenomena are present in the X-ray source X1822-37 and are attributed to the presence of an accretion disk corona (ADC). This description is consistent with the low ratio of X-ray-to-optical light found in CAL 87. That is, the X-ray engine is not viewed directly, but the detected X-rays are scattered into our line-of-sight by the ADC. Although a temperature variation should occur during eclipse of the corona, the count rate from CAL 87 is too low to see meaningful changes in the X-ray spectral distribution. The results of this investigation have been presented at scientific meetings and have been submitted for publication.

Publications:

- Cowley, A.P., Schmidtke, P.C., Frattare, L., McGrath, T., Crampton, D., and Hutchings, J.B. 1992, *Bull. Am. Astron. Soc.* **24**, 1154, "Optical Identification of X-ray Sources in the LMC using *ROSAT* Data".
- Schmidtke, P.C., and Cowley, A.P. 1992, in *Complementary Approaches to Double and Multiple Star Research*, IAU Col. No. 135, ed. H. A. McAlister and W. I. Hartkopf, *Astron. Soc. Pac. Conf. Ser.* **32**, 386, "Searching for X-ray Binaries in the LMC: The Optical Counterparts of CAL 9 and CAL E".
- Schmidtke, P.C., Cowley, A.P., McGrath, T., and Frattare, L. 1992, *Bull. Am. Astron. Soc.* **24**, 1154, "The X-ray Eclipse of the Black-Hole Binary CAL 87".
- Schmidtke, P.C., McGrath, T.K., Cowley, A.P., and Frattare, L.M. 1993, submitted, "The X-ray Eclipse of the LMC Binary CAL 87".